Configuration of Various Space Structures using Formex Algebra

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***Abstract* - A space frame or space structure is a truss-like, lightweight rigid structure constructed from interlocking struts in a geometric pattern. Space frames can be used to span large areas with few interior supports. There are numerous examples of space structures that are built for sports stadiums, gymnasiums, cultural centers, auditoriums, shopping malls, railway stations, aircraft hangars, leisure centers, transmission towers. A dome configuration is most suitable in space structure. Formex algebra is a comprehensive technique for algebraic representation and rapid processing of the configuration of any type of structure. Formex algebra is a mathematical system that consist of a set of abstract objects, known as formices and a number of rules in accordance with which these objects may be manipulated. Here various configurations of space structures are created using formex algebra. These configurations of space structures can be utilize in any professional structural software for the analysis and design.**

Keywords: Formex, Formices, Space Structure, Truss, Transmission Towers

I. INTRODUCTION

In the past, space structures were regarded as exotic and unconventional. Now they are used frequently in many countries around the world. The term 'spatial structure' is sometimes used instead of space structure. Like the truss, a space frame is strong because of the inherent rigidity of the triangle; flexing loads (bending moments) are transmitted as tension and compression loads along the length of each strut. The three-dimensional includes flat surfaces with loading perpendicular to the plane as well as curve surface. the term 'space structure' is simply used to refer to a number of families of structures that include grids, barrel vaults, domes, towers, cable nets, membrane systems, foldable assemblies and tensegrity forms. Space structures cover an enormous range of shapes and are constructed using different materials such as steel, aluminum, timber, concrete, fiber reinforced composites, glass, or a combination of these. There are numerous examples of space structures that are built for sports stadiums, gymnasiums, cultural centers, auditoriums, shopping malls, railway stations, aircraft hangars, leisure centers, transmission towers, radio telescopes, supernal structures (that is, structures for outer space) and many other purposes.

Space structures may be divided into three categories, namely, 'Lattice space structures' that consist of discrete, normally elongated elements, 'Continuous space structures' that consist of components such as slabs, shells, membranes, and 'Biform space structures' that consist of a combination of discrete and continuous parts. The behaviours of three classes of structure differ and their methods of analysis are also different. Of the above three types of structure, the skeleton or braced frame are also called latticed structures or space frames or reticulated structures. The overall shape of the surface and the pattern of the individual members of these structures may greatly affect their architectural appearance.

II. BASIC OF FORMEX FUNCTION

Formex algebra is a mathematical system that provides a convenient medium for configuration processing. The concepts are general and can be used in many fields. In particular, the ideas may be employed for generation of information about various aspects of structural systems such as element connectivity. Nodal coordinates, loading details, joint numbers and support arrangements. The information generated may be used for various purposes, such as graphic visualization or input data for structural analysis. The first textbook on the Formex algebra appeared in 1984. This book provided a comprehensive account of the ideas of formex algebra as they stood at the time of the publication. The book remains a main source of information on formex algebra although new developments in the field have superseded some of the material of the book. These new developments have also enriched this field of knowledge extensively. The term ‘configuration’ is used to mean an ‘arrangement of parts’. The elements of a structure, for instance, constitute a configuration and so do the component parts of an electrical network and the atoms of a protein molecule. The most common usage of the term configuration is in reference to geometric compositions that consist of points, lines and surfaces.

The term ‘configuration processing’ is used to mean the creation and manipulation of configurations and the term ‘formex configuration processing’ is used to mean configuration processing using formex algebra.

III. TRIMMED SCHWEDLER DOME

A Formian scheme for the generation of the configuration of this dome of fig 1. is shown. In this scheme

- The formex variable Ec represents the elements in the central region of the dome,
- The formex variable Eb represents the elements in the main body of the dome excluding the ones on the base ring,
- The formex variable B represents the elements on the base ring and
- The formex variable D represents all the elements of the dome.

```
(*)Trimmed Schwedler Dome(*)
Ec=rin(2,6,4)|{[1,0,0;1,0,1],
[1,0,1;1,4,1],[1,0,1;1,0,2],
[1,0,1;1,2,2],[1,2,2;1,4,1]}#
rin(2,12,2)|{[1,0,2;1,2,2],
[1,0,2;1,0,3],[1,0,2;1,2,3]}#
rin(2,12,2)|{[1,0,3;1,2,3],
[1,0,3;1,0,4],[1,0,3;1,1,4],[1,1,4;1,2,3]};
Eb=rinit(24,6,1,1)|{[1,0,4;1,1,4],
[1,0,4;1,0,5],[1,0,4;1,1,5]};
B=rin(2,24,1)|[1,0,10;1,1,10];
D=Ec#Eb#B;
DD=bs(25,360/24,3.5)|D;
use &,vm(2),Vt(2),
vh(0,50,100, 0,0,0, 0,0,1);
clear;
draw DD;
```

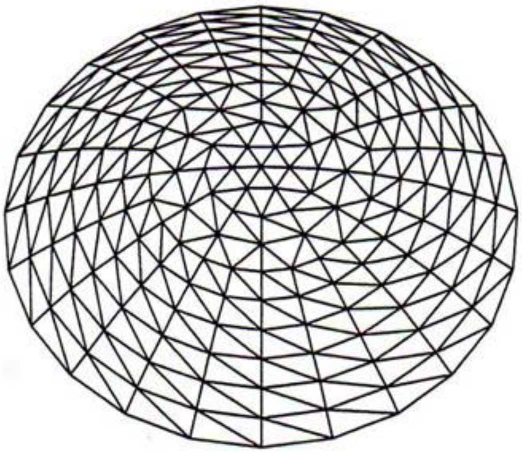

Fig 1. A trimmed Schwedler dome

IV. BARREL VAULT

A 'barrel vault' is obtained by 'arching' a grid along one direction. A barrel vault, also known as a tunnel vault or a wagon vault, is an architectural element formed by the extrusion of a single curve (or pair of curves, in the case of a pointed barrel vault) along a given distance. The curves are typically circular in shape, lending a semi-cylindrical appearance to the total design. The configuration of this Barrel valut shown in fig. 2.

```
(*) Barrel Vault  (*)
clear; m=10; n=10; r=10; e1=[r,0,0;r,1,1];
 e2=rinic(2,3,m,n,2,2)|lamic(2,3,1,1)|e1;
e3=lam(3,n)|rin(2,2*m,1)|[r,0,0;r,1,0];
e4=rinic(2,3,2*m+1,n,1,2)|[r,0,0;r,0,2];
ee=e1#e2#e3#e4; ee=bc(1,90/m,1)|ee;
 use vm(2),vt(1),vh(10,10,10,0,0,0,0,1,0);
draw ee;
```

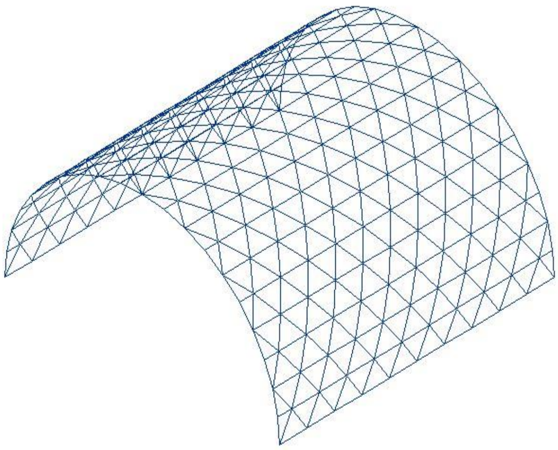

Fig 2. Barrel Vault

V. PAVILLION

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(*) Pavillion (*)
clear;
a1=rinid(13,36,1,1)|[0,0,0;0,1,0]
#rinid(12,37,1,1)|[0,0,0;1,0,0];
a2=bapel(3,6,0,6,36,12,4,4)|a1;
a3=bapel(2,0,18,12,18,36,24,28)|a2;
a4=rin(1,5,12)|a3;
use &,vm(2),vt(1),vh(-5,-5,12,0,0,0,0,0,1);
draw a4;
```

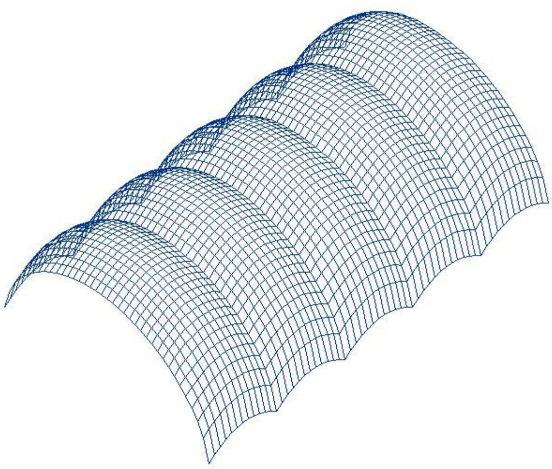

Fig 3. Pavillian

VI. NOVATION

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(*) Original (*)
clear; n=40;r=-8;c=1;
e=rinid(n,n,1,1)|[0,0,0;1,0,0;1,1,0;0,1,0];
(*)e=rinid(n,n,1,1)|rosad(.5,.5)|[0,0,0;1,0,0];
(*) use &,c(3,45),c(4,25),vm(2),vt(2),
vh(2*n,-2*n,2*n,n/2,n/2,0,n/2,n/2,1);
 draw e;
(*) Novation (Spots) (*)
clear; m=4;h=12;c=7; r=tic|(n/m);
a1=lib(i=2,tic|(n/r))|lib(j=2,tic|(n/r))|[r*(i-1),r*(j-1),0];
a2=lib(i=2,tic|(n/r))|lib(j=2,tic|(n/r))|[r*(i-1),r*(j-1),h];
en=nnov(2,c,a1,a2)|e;
use &,c(3,45),c(4,25),vm(2),vt(2),
vh(2*n,-2*n,2*n,n/2,n/2,0,n/2,n/2,1);
draw en;
```

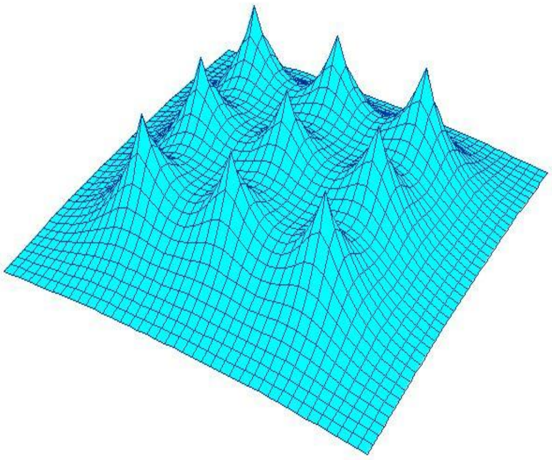

Fig 4. Novation

Similarly i have created different configuration for different types of other space structures also.

VII. CONCLUSIONS

1. Space structure configurations are elegant and impressive but, unless the designer is equipped with suitable conceptual tools, the task of generation of geometry is extremely difficult. Formex algebra stands alone as an algebra which provides a powerful mathematical basis for new approach to data generation. Formex configuration is emerging branch of generation of geometry of skeletal structures. It complements the human imagination and allows mentally visualized configuration to express in a concise and elegant manner & it is really proven efficient tool for modeling space structure.
2. Formian software provides a platform for formex configuration processing, generation of various types of structure like Braced Domes, Grids, Barrel Vaults, Pyramid, Towers, and Foldable System etc. This software not only generated the geometry but it is also integrated with other software like other internationally popular packages like ABACUS, LUSAS, and SAP etc. In addition to this it is also generated the data exchange file (*.dxf), which can imported in majority of CAD packages. This facility is efficiently exploited in present work.

VIII. REFERENCES

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